ASTR340: The Origin of the Universe

Prof. Richard Mushotzky

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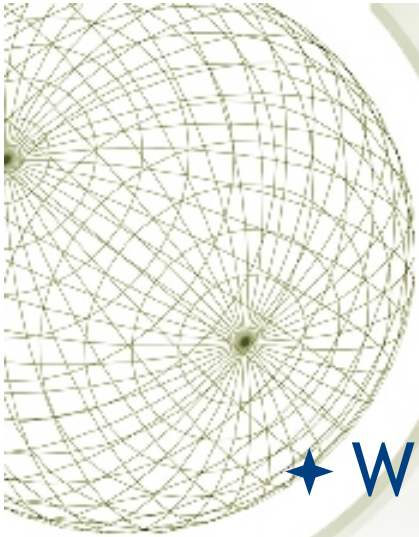
Office hours: 11:00-12:00am Tues/Thurs (just after class)

TA: **Kyle Elliott : kelliot2@terpmail.umd.edu**

Office hours: Tues/Thursday 5:00-6:00pm

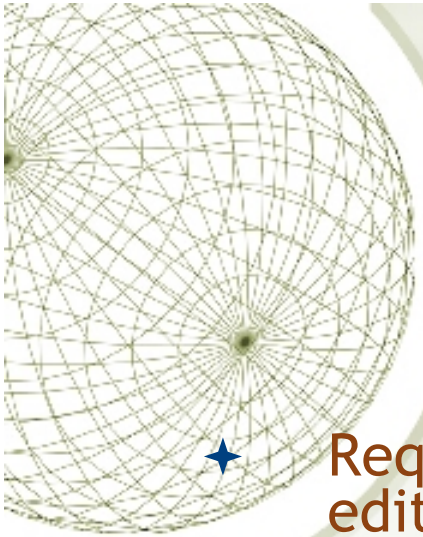
75 min class

NO OPEN LAPTOPS or USE of Cell Phones DURING LECTURES



Welcome!

- What is this course about?
- Logistics
  - Textbook, web pages
  - Pre-requisites
  - Assignments, exams, grading
  - Academic integrity
  - Semester plan
- Discussion
  - cosmogony -- myth and science



Textbook & web pages

- Required text: ***Foundations of Modern Cosmology*** (2nd edition) by Hawley & Holcomb
- Authors' web page:
  http://www.astro.virginia.edu/~jh8h/Foundations

- Course web page: see
http://www.astro.umd.edu
  - Information, syllabus, lecture schedule
  - Assignments
  - Past lectures
- Lectures will be posted on the web page *after* they are given

Pre-requisites

- Mathematics
  - High-school algebra, trigonometry and geometry
- Familiarity with astronomy at ASTR100 level
  - Course will be fairly self-contained
  - I will use basic astronomy terms freely (e.g. star, planet, galaxy), and will cover some topics quickly
  - **Consult chapters 4 and 5 of the textbook for review/refresher, as needed**
  - Please ask about anything when you are unsure or I am not clear !

Assignments & Grading

- Assignments:
  - Homework: 30%
  - Midterm : 30%
  - Final : 40%
  - TOTAL : 100%
  - *Class participation is encouraged*
- *Note: No "extra-credit projects"*

Letter grades

- Grading by:

Letter grade	Percentage
A	86-100
B	70-85
C	60-69
D	40-59
F	0-39

- I will adjust exam scores for a median of ~75% (low B) *if necessary*
- This means that homework is important!

Exams+ Other Info- academic calendar

http://registrar.umd.edu/calendar.html

- One mid-term, in class March 12th (last class before spring break) material up to lecture 13
- Tuesday, May 12, 2015 Last day of Spring classes
- Final exam, Friday, May 15 8:00-10:00am
- In event of a REAL EMERGENCY which forces you to miss an exam
  - Contact me prior to the exam- or as soon as possible
  - Document the emergency
- FEB 6 is last date to drop with a W
- Religious Holidays
  - Good Friday Fri., Apr 3, 2012
  - Passover Sundown, Friday, April 3*-Sunday, April 5, 2015

Emergencies Based on University Policy

- Regular attendance and participation in this class is best. However, if a class must be missed due to an illness, or other valid reason, the policy is:
  - For every necessary absence from class, a reasonable effort should be made to notify me or the TA in advance of the class. When returning to class, students must e-mail me or bring a note identifying the date of and reason for the absence.
- If a student is absent more than 5 time(s), documentation signed by a health care professional may be requested.
- If a student is absent on days when **tests are scheduled**, they should notify me in advance (if possible), and upon returning to class, bring documentation of the illness or personal reason.
- Please inform me of any other issue requiring special attention

Homework

- Homework assigned approx. once every two weeks
- HW is collected *at the start of class* on the due date (a week later)
  - **Please hand in on time**, or document the valid reason why it is late.
  - No credit after the day on which it is due, unless there is a justifiable reason.

Academic integrity

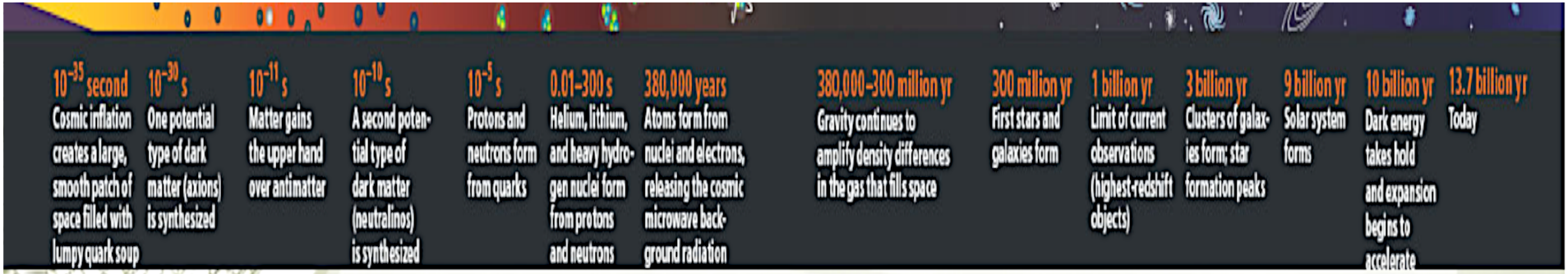
- **Always:**
  - Present your own thoughts in your own words
  - Cite any references that you use
- **Never:**
  - Copy from another student
  - Directly quote any published article unless you also give full credit to that article.
  - Allow other students to copy from you.
- Per campus policy, please write the honor pledge on each assignment

What is Cosmology

- Cosmology (from Greek κοσμολογια, kosmos, " universe " ; and λογια -logica, "the study of [a certain subject]"), is the study of the Universe in its **totality** as it is and was (or at least as it can be observed)
- Cosmology is as old as humankind- the 'need' to understand our surroundings (the universe) seems to be a primal need - it asks fundamental questions about the Universe, which border on philosophy.
- In the last 500 years, humanity has seen the predictions of fundamental physics converge with the observation of nature on a cosmic scale- *this is the theme of this class*

Cosmology

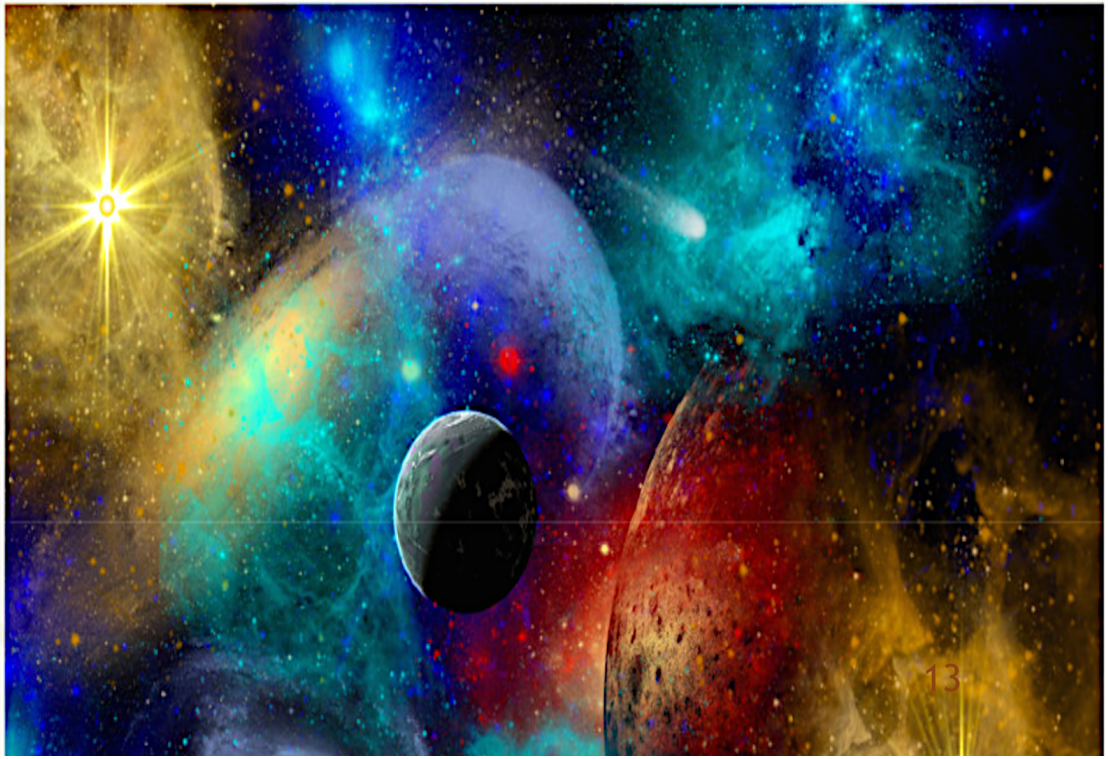
- The study of the Universe as a whole
  - What does the present-day Universe look like?
  - What was the history of the Universe?
  - What is the future of the Universe?
  - What make the whole thing "tick" ?
- These are amongst the biggest questions one can ask!
- We are going on an intellectual voyage across all of space and time



From Origin of the Universe
M.S. Turner Scientific American 301, 36 - 43 (2009)

"The Cosmos is all that is or ever was or ever will be" - Carl Sagan

Science is with us and all around us

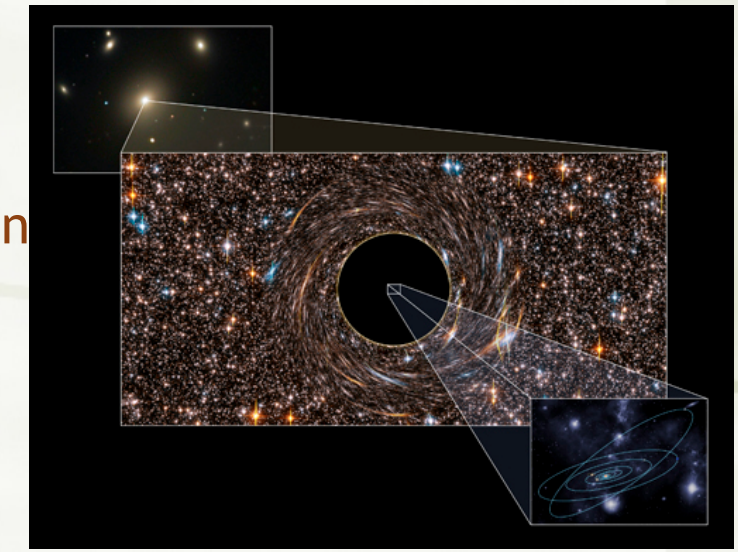


Most Important People of the Last Millennium (A&E Channel)

- 1 Johann Gutenberg (printing)
- 2 **Isaac Newton (gravity)**
- 3 Martin Luther (Protestant Reformation)
- 4 Charles Darwin (evolution)
- 5 William Shakespeare (playwright)
- 6 Christopher Columbus (explorer)
- 7 Karl Marx (19th c. political writer)
- **8 Albert Einstein (physicist)**
- **9 Nicolaus Copernicus (astronomy)**
- **10 Galileo Galilei (astronomy)**

People in **red** figure prominently in this class

Topics we will cover



- Early history of cosmology
- The laws that govern the Universe
  - Newton's laws of motion and gravitation
  - Einstein's Theory of Relativity
    - Black holes
- Observations of the Universe
  - The universe is expanding!
  - How did the contents of the universe originate?
- The Big Bang Theory
  - What is it…
  - … and why do we think its right?
- Physics of the very early universe- beyond the cutting edge

- This is an **enormous** range of material; much of the progress in **physics** the last 500 years is crucial to this field

Discussion: myth and science in cosmogony

Throughout history, all cultures have sought to make the Cosmos intelligible, imposing order and addressing timeless questions:

- Has the heavens and Earth existed forever?
  - If not, how did it all begin?
- Is the Universe unendingly large (infinite), does it have a boundary?
- What is the future of the Universe -will it come to an end?
- What are the constituents of the Universe?
- What are the laws by which the Universe "works"?

- *What are your questions?*

- *Cosmogony* = an explanation of the origin and evolution of the Universe
- *Cosmology* =the **scientific** study of the formation, structure, and evolution of the Universe

Creation myths

- Myths may be meant literally or figuratively
- Mythology reflects what is important to a culture, e.g.
  - revolved around seasons, planting & harvesting for agricultural societies
  - involve animals with human characteristics for hunter-gathering peoples
- Creation myths share common themes
  - Use imagery to describe origins/formation of the Universe:
    e.g creation from seed/egg; supreme craftsman; order from chaos
  - Use past events to explain aspects of the human condition
  - Involve catastrophes and supernatural occurrences
  - Establish relationships among animals, humans, gods
  - Assert the centrality of humans to the Cosmos
  - Explain how things are and came to be

The scientific method

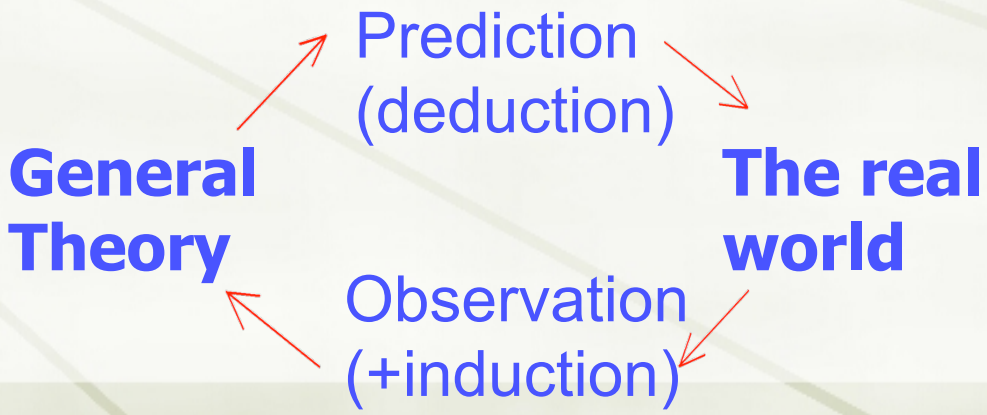
- Relevant (explanatory power)
- Consistent (within and without)
- Predictive (qualitative and quantitative)
- Testable (falsifiable)
- Simple (Occam's razor)

A hypothesis that survives significant tests of many of its predictions can become a *theory*, and perhaps even a *law*.

Science is **always** a work in progress

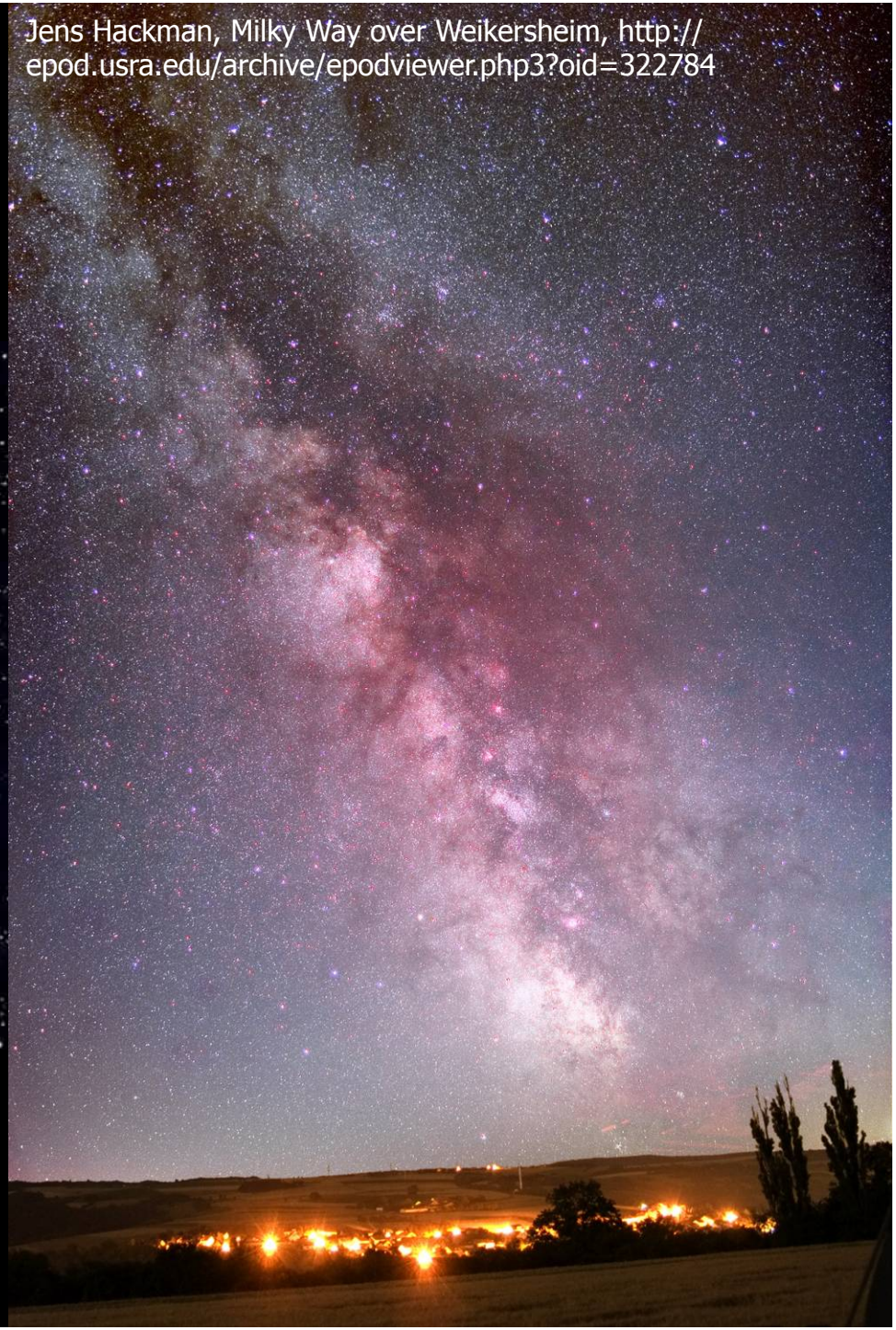
Scientific cosmology

- Non-anthropocentric
- Based on concept of causality, but not purpose
- Derives from data = objective (reproducible), quantitative observations of the physical world
- Models/theories are continually re-evaluated based on the *scientific method (testable via observation or experiment)*
- To be scientific, *a theory must be falsifiable* : whole or part may be rejected based on new data
- New data can support an existing theory, but cannot **prove it**



The Galaxy

Andromeda

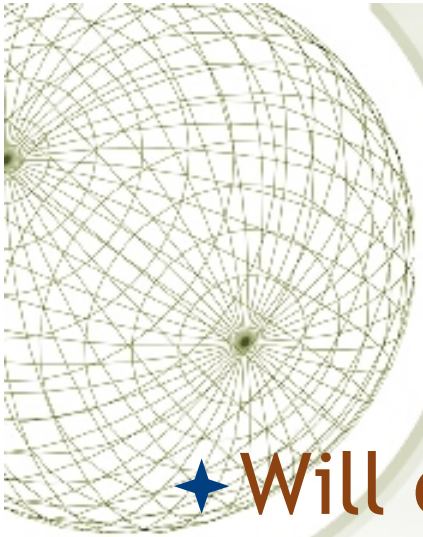


Jens Hackman, Milky Way over Weikersheim, http://epod.usra.edu/archive/epodviewer.php3?oid=322784


Hubble space telescope Ultra
Deep Field (S. Beckwith et al.)
The Universe

Future Lectures- See the Syllabus

Lec 2 Early Ideas about Cosmology	Ch 1-2
Lec 3 Cosmology of the Scientific Revolution: Tycho , Galileo, Newton	Ch 2-3
Lecs 4-5 Newtonian Physics	Ch 3
Lec 6- Principles of Space and Time	Ch 6
Lecs 7-9 Special Relativity	Ch 7
Lec 10-11 General Relativity	Ch 8
Lec 12 General Relativity, Black Holes	Ch 9
Lec 13 Black Holes, Expanding Universe	Ch 10
EXAM	



Next Time…

- Will discuss
  - Classical (geocentric) model of the Universe
  - Observations and ideas of the Renaissance
- *Please read Chapter 1 of the book*
- *Read Chapter 2 next week*
- First HW assigned Thursday next week